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**SATELLITE NETWORKS:  
ARCHITECTURES, APPLICATIONS, &  
TECHNOLOGIES WORKSHOP**

June 3, 1998  
Cleveland, OH

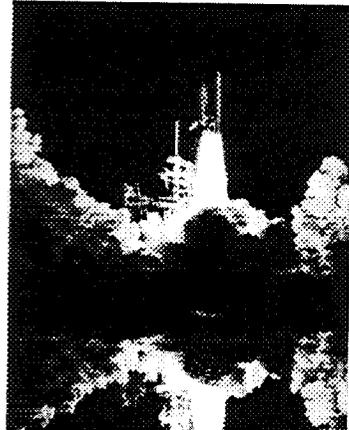
**“NEW OPPORTUNITIES WITH  
THE ADVANCED COMMUNICATIONS  
TECHNOLOGY SATELLITE (ACTS)”**

Robert Bauer  
ACTS Project Manager  
NASA Lewis Research Center

  
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**ACTS PROGRAM OVERVIEW**

- Experiments began December 6, 1993.
- Initial 2 year mission life extended to 4 years (design life).
- Fifth year now underway.
- Over 100 organizations involved in 85 experiments; 81 demonstrations to various audiences.

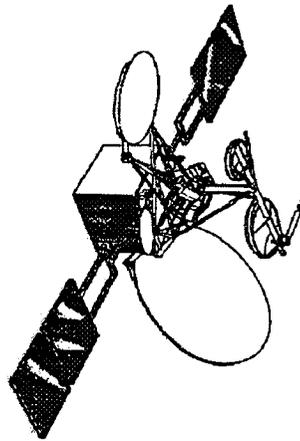


Launched September 12, 1993.



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# ACTS SPACECRAFT CHARACTERISTICS

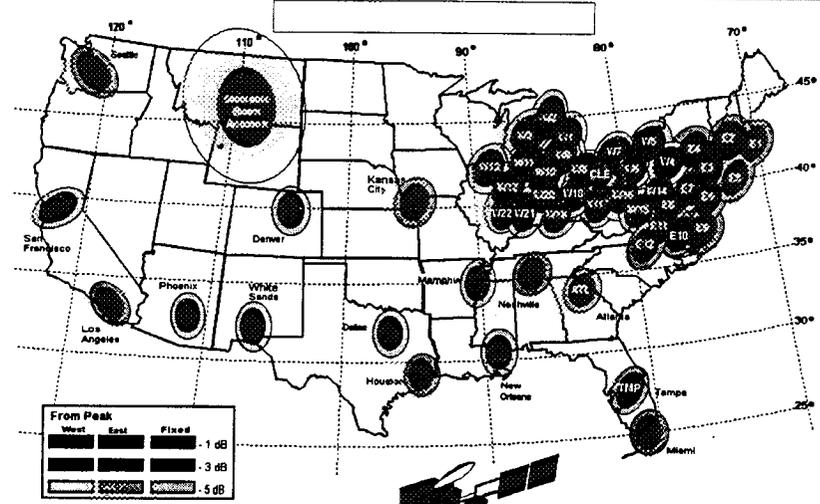


- **Weight:** 3250 lbs (on-orbit)
- **Power:** 1770 BOL
- **Frequency Band:** Ka (30/20 GHz)
- **Space Pointing (Pitch & Roll) Accuracy:**  $\pm 0.025^\circ$
- **Launch Date:** September 12, 1993
- **Stationkeeping Fuel Expended:** Projected July, 1998
- **Inclined Orbit Operations (N/S not maintained):** Through September, 2000



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# SPOT BEAM LOCATIONS





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## KEY ACTS TECHNOLOGIES

### High Gain, Fast Hopping Spot Beams

- EIRP >64 dB
- G/T >20 dB/K
- Frequency Reuse > 4

### Onboard Processing & Switching

- Baseband Switching at 64 kbps circuit level
  - Max throughput of 220 Mbps
  - Full mesh, single hop connectivity
- Wideband Switch Matrix of 3 channels at 900 MHz each

### Ka-Band

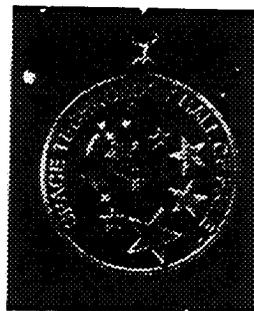
- 30/20 GHz RF spacecraft & earth station components
- Propagation measurements to characterize band
- Adaptive rain fade compensation
- Only currently available 30/20 GHz satellite testbed in U.S.



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## ACTS ACCOMPLISHMENTS (selected)

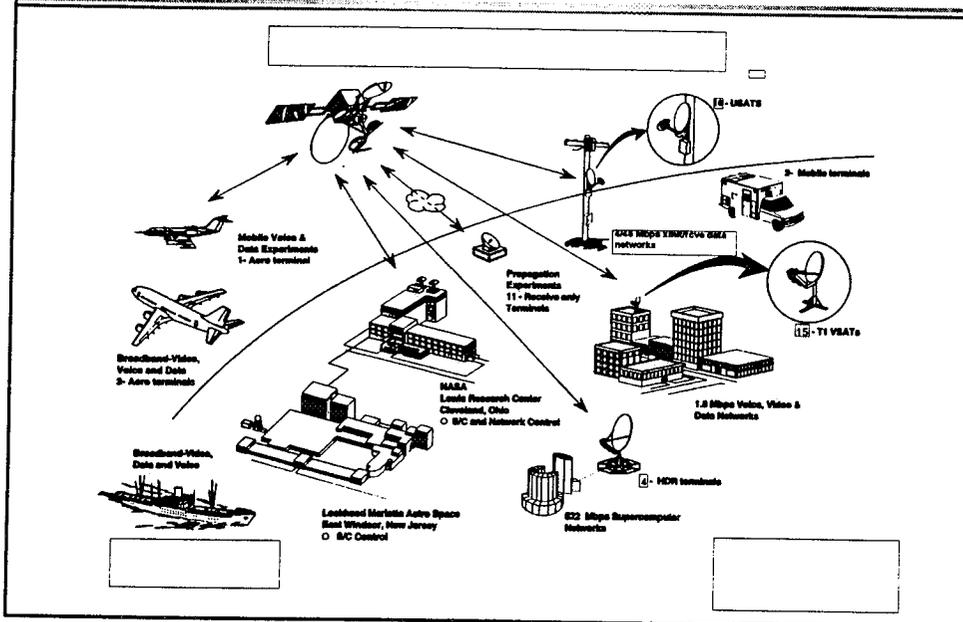
- Inducted into Space Technology Hall of Fame, April 1997.
- Highest known data rates supported in a single transponder by a non-DoD satellite (622 Mbps).
- Experiments have been supported in 31 states and 6 foreign countries.
  - Using multiple satellites, have linked to Europe and Asia.
- Experiments and demonstrations:
  - from planes, trains, automobiles, and ships
  - from volcanoes, deserts, rain forests, islands, and battlefields
  - with scientists & engineers, patients & doctors, politicians & soldiers, educators & students...





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# ACTS EXPERIMENTS OPERATIONS



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# INCLINED ORBIT OPPORTUNITY

## WHY EXTEND THE PROGRAM??

- ✓ Successful experiments program.
  - ✓ Sustained interest and impressive results have driven the desire to continue ACTS as long as reasonable/possible.
- ✓ Minimal further cost to achieve maximum benefit from investment to NASA and Nation.
  - ✓ Program constraints define end of life at September, 2000.
- ✓ Test viability of narrow spot beam system in IO.
- ✓ No failure of primary systems.
- ✓ Efficient stationkeeping
  - ✓ Calculations show sufficient fuel to operate for 30 mos. in inclined orbit.
  - ✓ Maintain spacecraft at  $100^\circ \pm 0.05^\circ$  West longitude.



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## INCLINED ORBIT MISSION

- Prepare the system for supporting inclined orbit operations.
  - Implement new spacecraft procedures to maintain attitude.
  - Install and test modified ground segment.
- Continue operations with a tracking ground segment to support program plans and experiment operations requirements through September 2000.

***Minimize impact to experiment operations***



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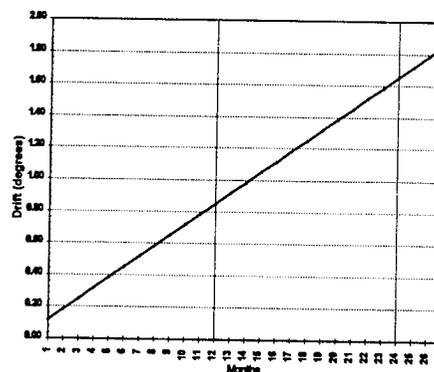
## INCLINED ORBIT IMPACT

### Spacecraft

- Satellite will drift in N/S direction increasing by  $\sim 0.8^\circ$  per year
- ACTS East/West maintained at  $\pm 0.05^\circ$  for up to 27 months.
- Last North/South maneuver planned for July, 1998.
- About 1 month for S/C to exceed  $0.05^\circ$

### Ground Segment

- Tracking modifications underway (2 axis)



ACTS Drift Inclination



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# MODIFICATIONS SUMMARY



| ITEM   | SPACECRAFT | MGS            | T1VSAT   | HDR                      | USAT                  | LET      |
|--|------------|----------------|----------|--------------------------|-----------------------|----------|
| Assets / IO Ready                                  | 1/1        | 1/1            | 19/15    | 6/3                      | 10/10                 | 1/1      |
| Contractor   | LMAS       | Comsat         | Harris   | BBN                      | -                     | -        |
| Ant. Diam. (m)                                     | 3.3/2.2    | 5.0            | 1.2'     | 3.4                      | .6 (.35,1.2)          | 4.7      |
| HPA (w)  | 46         | 130            | 10       | 120                      | 1                     | 100      |
| Ant. HPBW (deg) <sup>2</sup>                       | -          | .1             | .5       | .2                       | 1.0(1.8,0.5)          | .12      |
| Trng. Needed (months past last NYS, -3 dB, 30 GHz) | -          | .5             | 3.5      | 1                        | 7 (13, 3.5)           | .75      |
| H/W Mods   | N          | N              | Y        | Y                        | Y                     | Y        |
| S/W Mods   | Y          | N <sup>3</sup> | Y        | Y                        | N <sup>4</sup>        | Y        |
| User Data Rates                                    | -          | 50.2/18.8 Mbps | 1.8 Mbps | OC3 -OC12 (155-622 Mbps) | 4/45 Mbps (xmit/rxve) | 220 Mbps |

### NOTES

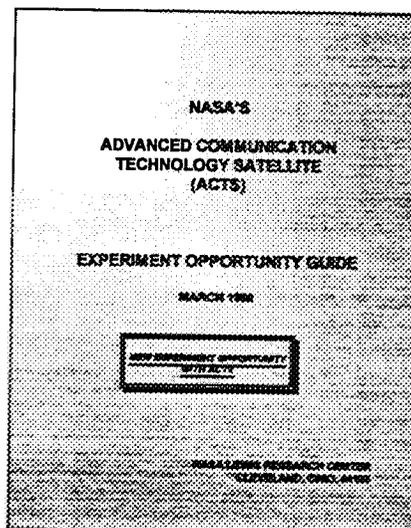
1. 2.4 m dish not being modified for I/O.
2. Calculated values.
3. No impact to BBP for up to 24 months of I/O.
4. TDMA network being developed, S/W mods will be evaluated when implemented.



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# EXPERIMENT OPPORTUNITY

- **Experiments Opportunity Guide** released March, 1998.  
(<http://kronos.lerc.nasa.gov/acts/eoa/guide.html>)
- 4 experiments categories defined.





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## EXPERIMENT CATEGORIES

1. Demonstrate transitioning to future commercial satellite services in support of NASA & other government missions.
2. Test, verify & resolve technical issues using Asynchronous Transfer Mode (ATM), Internet Protocol (IP), or other protocols over satellite, including interoperability issues with terrestrial networks.
3. Characterization of the ACTS system and operations in inclined orbit.
4. Verify new satellite Ka-band technology and hardware.



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## RECENT ACTIVITY

- "Testing New Modalities of Space Communications"
  - Major aerospace firm and team of several networking hardware and software providers.
  - Demonstrate network and protocols that could lead to consolidation of NASA space operations.
- FTP, TCP/IP, HTTP testing over ACTS
  - Ohio University and LeRC collaboration



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## ONGOING ACTIVITY

### #118x ("High Speed Protocol Optimazation")

- Dispell myth that GEO satellites and TCP/IP are incompatible.
  - Investigate protocol performance on a multi-platform, geosync satellite network
  - OC-3 & OC-12 rates; symmetric & asymmetric links
  - Optimize point-to-point transfer of data between two sites across ACTS (HDR's at LLNL and LeRC)
  - Use TCP/IP over Asynchronous Transfer Mode (ATM) among multiple computer platforms and operating systems.
  - Wide variety of partners including top names in industry:
    - Computer Industry - 7 orgs.
    - Communications Industry - 4 orgs
    - Satellite Industry - 6 orgs
    - Government Laboratories - 4 orgs



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## EXPERIMENT PROCESS

- Submit **Letter of Intent**, or better yet...
- Submit **experiment proposal**.
- Review for feasibility (S/C, ground segment, schedule), meets goals.
- Space Act or other appropriate agreement developed with all experimenters.
  - ensures requirements defined
  - most agreements are reimbursable
  - benefits Experimenter as well as NASA by clarifying what's expected of both parties.



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## ACTS EXPERIMENTS POINT OF CONTACT

- **ACTS Project**  
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- **ACTS Home page**  
**<http://acts.lerc.nasa.gov>**